Journal of Modern Physics, 2025, 16(10), 1415-1437
https://www.scirp.org/journal/jmp
ISSN Online: 2153-120X
ISSN Print: 2153-1196

Are Phonons and Random Thermal Motions Evidence of Magnetic Monopoles?

Golden Gadzirayi Nyambuya

Department of Applied Physics, Faculty of Applied Sciences, National University of Science & Technology, Bulawayo, Republic of Zimbabwe
Email: physicist.ggn@gmail.com

How to cite this paper: Nyambuya, G.G. (2025) Are Phonons and Random Thermal Motions Evidence of Magnetic Monopoles? *Journal of Modern Physics*, **16**, 1415-1437.
https://doi.org/10.4236/jmp.2025.1610069

Received: May 15, 2025
Accepted: October 12, 2025
Published: October 15, 2025

Abstract

Phonons are indeed recognized as vibrations of the lattice that transport heat energy in solids. To contemplate on the idea of whether or not these vibrations might be associated with magnetic monopoles seems, at first glance, nonsensical. What connection could exist between lattice vibrations and magnetic monopoles? Magnetic monopoles are often viewed as exotic particles, theorized to exist under extreme conditions—such as those present at the birth of the Universe. Yet, here we find ourselves contemplating whether these elusive particles could be linked to the thermodynamic mechanisms behind lattice vibrations in solids. This invites a deeper exploration of the interplay between different realms of physics. We invite and encourage our reader to embark on this intellectual journey with us as we delve into the deep end of the fabric of physical and natural reality. Together, we can marvel at, and, investigate the operations of *Nature* at Her most elementary and fundamental level of reality, seeking to understand how seemingly disparate phenomena might intertwine in unexpected ways. By examining the plausible connections between phonons and magnetic monopoles, we might uncover new and deeper insights into the fundamental principles governing the transport of heat energy and the nature of matter itself.

Keywords

Dyon, Fuorier's Heat Equation, Magnetic Monopole, Phonon

1. Introduction

According to Kittel and Kroemer ([1]: p. 103), the energy of an elastic wave in a solid is quantized just as is the case with the energy of an electromagnetic wave in a cavity is quantized and the quantum of energy of these elastic waves is what is called a Phonon. In other words, Phonons are vibrations of the lattice that transport heat energy in solids [2]. Now, to ask whether or not these vibrations might have something to do with the elusive magnetic monopoles predicted by the great British fundamental theoretical physicist—Paul Adrian Maurice Dirac (1902-1984) [3], at any rate imaginable—this appears far-fetched a connection—if not outright nonsensical, to say the very least. Be that as it may, we have our just and immutable reasons for thinking this. As such, we invite our reader to take this thrill-some journey with us—*i.e.*, the journey of the subtle logical reasoning leading to this rather bizarre and outlandish conclusion.

Surely, what—*if any at all*—have these vibrations to do with magnetic monopoles? At any rate imaginable, the hypothetical magnetic monopoles are thought of as being exotic particles that are believed to only exist freely in the extreme physical conditions such as at the supposed birth of the Universe—*yet*—here we are, asking if these particles are not what causes vibrations of the lattice in solids?! Against these odds, we once again and with great confidence, invite the reader to take a journey with us as we peer deeper into reality than meets the mundane eye as we probe this seemingly far-fetched and nonsensical question.

Of magnetic monopoles, it was in 1931 (see Ref. [3]) while studying the hypothetical quantum mechanical case of the motion of an electronic charge inside a magnetic monopole field, Dirac came to the most beautiful, deepest and completely unexpected conclusion that he could only consistently define the quantum mechanical wavefunction *if and only if* the electronic, q, and magnetic charge, g, satisfied the following quantization condition:

$$\mu q g = \frac{1}{2} n\hbar, \quad \text{where } n = 0, \pm 1, \pm 2, \pm 3, \text{etc.} \tag{1}$$

After about seventeen years of esoteric pondering on this result [*i.e.*, Equation (1)], Dirac [4] realised that the deepest meaning of his most beautiful quantization condition, is that—if at least just one and only one magnetic monopole with a magnetic charge g in-accord with Equation (1) exists anywhere in the Universe—however remote this place may be in the Universe, then, all electronic charge anywhere in the Universe must come in units of: $e = \hbar / 2\mu g$. He (Dirac) wrote [4]:

> "*Thus the mere existence of one pole of strength* g *would require all electric charges to be quantised in units of* $\hbar / 2\mu g$."

More discretely said—the existence of just one and only one magnetic monopole anywhere in the Universe, is more than sufficient to explain why all electronic charges must be quantized in units of a fundamental unit of electronic charge e. Without any doubt, this is one of the most profound intellectual insights to ever come from the human mind and one cannot help but admire the great, esoteric and subtle mind of the great Paul Dirac. Consequently, this (*i.e.*, the existence of just one magnetic monopole) should explain why the magnitude of the electronic charge of the Electron and Proton should *not only* be equal, but, the same no matter which Electron or Proton one is considering.

Dirac's esoteric result is so profound so much so that, the none detection of at least one of these exotic particles has sent most—*if not all*—fundamental theoretical physicists to unambiguously express their desperation in their prophesied existence. They hold-fast that Dirac's profound result seems to be the only hope and way to justify from a most fundamental theoretical level imaginable, why electronic charge strongly appears to be quantized. Despite the obvious great odds before them, fundamental theoretical physicists continue to strongly holding-fast to their now *infinitely thin hope* that one-day, the magnetic monopole will be found.

If the thesis presented herein is correct, acceptable or anything to go by, well then, magnetic monopoles may very be all around (and within) us, with each and every particle carrying at least a pair. With very strong reasons, we here conjecture that the evidence of their existence may very well be the ubiquitous *quantum randomness* whose nature and origins has perplexed physicists ever-since.

In § (2), we shall present an exposition of Maxwell's equations of electrodynamics and the major highlight of this exposition is not Maxwell's equation *per se*, but our visitation to the very dustbins of the *History of Physics*. Specifically, we visit Maxwell's dustbin and retrieve from it the very equations that Maxwell rejected while on his great journey to discover the four iconic equations that now bare his name. As is well known, Maxwell came to discover his equations not because he had set himself the task to do so, but wanted to write a summary of all the known knowledge of electricity and magnetism at the time. That is all that he wanted to do. If he had done just that, he may not even be remembered today, as what he would have achieved would been as good as any mundane review work that only helps workers living in those immediate and adjacent times before new knowledge paves its way.

But Maxwell was no ordinary gentleman—he was a great consummate and logical thinker. After having collected all the knowledge of electricity and magnetism that was in existence at the time, he made a final check at the consistency of these equations. Being a great consummate and logical thinker that he was, he found that it was not enough to simple say "*here is all the knowledge of electricity and magnetism thus far*". Much to his fortune, he checked the summary of knowledge he had gathered for self-consistency and to his dissatisfaction, he discovered an embarrassing hole that needed to be filled forthwith. The embarrassing hole was deep in the nimbus of *Ampere's Law*.

That is to say—*Ampere's Law* made the four equations of electromagnetism to be non-self-consistent with respect to the conservation of both electronic charge and current in the case of dynamic systems. To fix this hole, the great Maxwell made a most daring and esoteric hypothesis whereby he postulated the existence of a *hitherto* yet unknown displacement current. This displacement current was constrained so that it made these four equations of electromagnetism to be consistent with the *Law of Conservation* of both electronic charge and current. The rest is now common history presented in every good physics textbook.

Common wisdom holds that in the noble endeavour called *Science*, a great place to look for ideas is the *Dustbin of Science—for there-in*—some of these discarded and rejected ideas may have come well before their time. To that end, in § (3), we take and polish the equations that Maxwell rejected whereby, we use them not to describe electric monopoles but magnetic monopoles. In § (5), when we try to interrogate these monopole equations, that is, interrogate them on what kind of waves would proceed from them—much to our surprise, we arrive at the—*Heat Equation*. This rather serendipitous result strongly suggests to us that if indeed magnetic monopoles are described by the equations that Maxwell rejected, then, these monopoles may very well be present in all matter and may be the very drivers of thermodynamics. Before we pre-empty all that we are going to do in this reading, we are going to stop this introduction right here and proceed forthwith to do the afore-described job.

2. Maxwell's Equations

Rightly so, the great and *avant-grade* Scottish fundamental theoretical physicist and mathematician—James Clerk Maxwell (1831-1879) is universally considered as one of the greatest figures in all of humanity's intellectual discourse and as-well in the *History of Science*. This pre-eminent position is rightly attributed to Maxwell not so much for the number and the relevance of his scientific contributes, but for the shear depth and nature of the importance of the unifying nature of his esoteric contributions to *Science*.

Just as the great Sir Isaac Newton (1642-1727) before him and Albert Einstein (1879-1955) after him, Maxwell [5] introduced into physics new and deeper ways of looking at physical and natural phenomena—thus, opening completely new intellectual and conceptual (and practical) horizons in-which process, he modified the scientific body of accepted theories and physical conceptions (and metaphysical conceptions as-well). At the pinnacle, apex and zenith of his rare and agile intellectual prowess, he conducted an in-depth and meticulous study of electricity and magnetism, in which process he cast knowledge in this field into its present enduring form. He provided the necessary mathematical framework that the great Michael Faraday (1791-1867) was not able to workout because of his [Faraday] mathematical shortcomings and handicapness.

Using Faraday's brilliant and ingenious concept of field lines, Maxwell made analogues between fluid flow and the magnetic and electric field lines of force. It is this envisionment that enabled him to gain a deeper understanding of the electrodynamic phenomenon thus leading him to neatly casting Faraday's work into its current mathematical form. The sagacious intellect of Maxwell collected the three equations, *i.e.*:

1) *Faraday's Law of Electromagnetic Induction*.
2) *Coloumb's Law of Electrostatics*.
3) *Amperé's Law of Magnetic Field Generation by a Moving Electric Charge*.

Before doing that, from his fluid analogues of magnetic field lines (as developed by Michael Faraday before him) and the concept of conservation of flux, Maxwell summarised the fact that magnetic field lines, $\boldsymbol{B}_{\mathrm{e}}$, are always closed by writing this fact in its mathematical form as: $\nabla \cdot \boldsymbol{B}_{\mathrm{e}} = 0$. So, in one of the greatest achievements of the human mind—an outstanding achievement of *mind-over-matter*; Maxwell now had four equations that formed a complete and supposedly consistent set of equations describing the electromagnetic phenomenon and these equations are:

$$\nabla \cdot \boldsymbol{E}_{\mathrm{e}} = \frac{\varrho_{\mathrm{e}}}{\varepsilon_{\mathrm{e}}}, \tag{2a}$$

$$\nabla \times \boldsymbol{E}_{\mathrm{e}} = -\frac{\partial \boldsymbol{B}_{\mathrm{e}}}{\partial t}, \tag{2b}$$

$$\nabla \cdot \boldsymbol{B}_{\mathrm{e}} = 0, \tag{2c}$$

$$\nabla \times \boldsymbol{B}_{\mathrm{e}} = \mu_{\mathrm{e}} \boldsymbol{J}_{\mathrm{e}}. \tag{2d}$$

If complete, these four equations should be able to describe *Electrodynamcs* in a self-consistent manner.

However, the agile, meticulous and consummate mind of Maxwell made one closer look at them by inspecting Ampére's Law [Equation (2d)] against the *Law of Conservation of Electronic Charge and Current*. His inspection led him to the conclusion that—*for the case of a time varying electric phenomenon*—this equation was not consistent with this seemingly *Sacrosanct Conservation Law*. In a nutshell, this meant that these equations are not self-consistent and thus cannot describe *Electrodynamcs* in a self-consistent manner. In-order to see this, one simple has to take the divergence of Equation (2d) and remember that the divergence of a curl of any vector field is identically equal to zero, *i.e.*:

$$\nabla \cdot \left(\nabla \times \boldsymbol{B}_{\mathrm{e}} \right) \equiv 0. \tag{3}$$

Consequently, this means:

$$\nabla \cdot \boldsymbol{J}_{\mathrm{e}} \equiv 0. \tag{4}$$

For a time varying electrical charge density distribution, Equation (4) is not consistent with the *Law of Conservation of Electronic Charge and Current* with the happenings in such a set-up. The correct equation which consistently describe the goings-on and happenings thereof, in such a set-up, is:

$$0 = \frac{\partial \varrho_{\mathrm{e}}}{\partial t} + \nabla \cdot \boldsymbol{J}_{\mathrm{e}}, \tag{5}$$

thus in Equation (4), the term $\partial \varrho / \partial t$, is missing.

To make them self-consistent—*perhaps, though some divine intercession*—Maxwell fore-conceived of the (then) hypothetical concept of *displacement current* and thus proceeded without detour, to add—by the *sleight of hand*, an extra-term to Amperé's Equation (2d), *i.e.*:

$$\nabla \times \boldsymbol{B}_{\mathrm{e}} = \mu_{\mathrm{e}} \boldsymbol{J}_{\mathrm{e}} + \mu_{\mathrm{e}} \boldsymbol{J}_{\mathrm{D}}, \tag{6}$$

where: $\boldsymbol{J}_{\mathrm{D}}$, is what Maxwell called the *displacement current density*, and, $\mu_{\mathrm{e}} \boldsymbol{J}_{\mathrm{D}}$, is the said extra-term that Maxwell added. With this hypothetical displacement current now in place; Maxwell tried again take the divergence of Ampére modified law [*i.e.*, Equation (6)], so doing, he obtained:

$$\nabla\cdot\boldsymbol{J}_{\mathrm{e}}+\nabla\cdot\boldsymbol{J}_{\mathrm{D}}\equiv 0. \tag{7}$$

Unflinching in his belief in the correctness of Equation (6), Maxwell required of Equation (7); that—it must be identical to the electronic charge continuity Equation (5). So, by comparing these equations [*i.e.*, Equations (7) and (5)], Maxwell obtained that:

$$\frac{\partial\varrho_{\mathrm{e}}}{\partial t}\equiv\nabla\cdot\boldsymbol{J}_{\mathrm{D}}. \tag{8}$$

Henceforth, from Equation (2a), it follows that we will have that: $\varrho_{\mathrm{e}}=\varepsilon_{\mathrm{e}}\nabla\cdot\boldsymbol{E}_{\mathrm{e}}$. So, Maxwell substituted this equation: $\varrho_{\mathrm{e}}=\varepsilon_{\mathrm{e}}\nabla\cdot\boldsymbol{E}_{\mathrm{e}}$, into the identity Equation (8), where upon he obtained that for this identity to hold, one must have:

$$\boldsymbol{J}_{\mathrm{D}}=\varepsilon_{\mathrm{e}}\frac{\partial\boldsymbol{E}_{\mathrm{e}}}{\partial t}. \tag{9}$$

Substituting this back into the modified Ampére's Equation (6), one obtains:

$$\nabla\times\boldsymbol{B}_{\mathrm{e}}=\mu_{\mathrm{e}}\boldsymbol{J}_{\mathrm{e}}+\frac{1}{c^2}\frac{\partial\boldsymbol{E}_{\mathrm{e}}}{\partial t}, \tag{10}$$

where: $c=1/\sqrt{\mu\varepsilon}$, is the speed of Light. In a great show of faith and confidence in established *Physical Laws—i.e., without going into the laboratory to conduct experiments to verify his strong intuition*—this is how the great and subtle Maxwell used the *sleight of mind* to modify Ampére's Equation (6).

Collecting all these equations, Maxwell went on to build his iconic, his most beautiful, his most seductive, his most admirable—most legendary and enduring *Classical Theory of Electrodynamics*. That is to say, the resulting five self-consistent equations, are:

$$\nabla\cdot\boldsymbol{E}_{\mathrm{e}}=\frac{\varrho_{\mathrm{e}}}{\varepsilon_{\mathrm{e}}}, \tag{11a}$$

$$\nabla\times\boldsymbol{E}_{\mathrm{e}}+\frac{1}{c}\frac{\partial\left(c\boldsymbol{B}_{\mathrm{e}}\right)}{\partial t}=0, \tag{11b}$$

$$\nabla\cdot\left(c\boldsymbol{B}_{\mathrm{e}}\right)=0, \tag{11c}$$

$$\nabla\times\left(c\boldsymbol{B}_{\mathrm{e}}\right)-\frac{1}{c}\frac{\partial\boldsymbol{E}_{\mathrm{e}}}{\partial t}=\mu_{\mathrm{e}}c\boldsymbol{J}_{\mathrm{e}}, \tag{11d}$$

and:

$$\frac{1}{c}\frac{\partial\left(\varrho_{\mathrm{e}}c\right)}{\partial t}=-\nabla\cdot\boldsymbol{J}_{\mathrm{e}}. \tag{12}$$

For the equation of motion for a charged particle in a combined electric and magnetic field, we have the Lorentz equation of motion—namely:

$$\boldsymbol{F}_{\mathrm{e}}=q\boldsymbol{E}_{\mathrm{e}}+q\left(\frac{\boldsymbol{v}}{c}\right)\times\left(c\boldsymbol{B}_{\mathrm{e}}\right). \tag{13}$$

where: q and $\boldsymbol{v}$, are the charge and velocity of the electric monopole respectively. As already stated:

$$c = \frac{1}{\sqrt{\mu_{\mathrm{e}}\varepsilon_{\mathrm{e}}}} = \frac{c_0}{\sqrt{\mu_{\mathrm{e}}^r\varepsilon_{\mathrm{e}}^r}} = \frac{c_0}{n_{\mathrm{e}}}, \tag{14}$$

is the speed of Light—with: μ_{e}^r, $\varepsilon_{\mathrm{e}}^r$, and $n_{\mathrm{e}} = \sqrt{\mu_{\mathrm{e}}^r\varepsilon_{\mathrm{e}}^r}$, being the relative electro-monopole permittivity and permeability of the given medium, and the electro-monopole refractive index of this same medium.

Because in § (5) we will need to make a comparison of the energy, $\mathcal{Q}_m$, stored in a magnetic monopole field with that of the electromagnetic, $\mathcal{E}$, stored in an electromagnetic system of volume V, we will here and now write down the expression for this electromagnetic, $\mathcal{E}$. That is to say, $\mathcal{E}$, such that:

$$\mathcal{E} = \frac{1}{2}\varepsilon_{\mathrm{e}}\left(\left|\boldsymbol{E}_{\mathrm{e}}\right|^2 + c^2\left|\boldsymbol{B}_{\mathrm{e}}\right|^2\right)V. \tag{15}$$

By way of analogue, without making any derivation, in § (5) at the instance of Equation (32), we shall express the energy of a magnetic monopole field in the same manner as that of an electromagnetic field as given in Equation (15). It for this reason that we have written this expression down.

In-closing this section, for latter purposes, it is important to note that the dimensions and SI Units for all the physical quantities appearing in Equations (11), (12) and (13) are as follows:

1) $[\mu_{\mathrm{e}}] = \mathrm{M}\cdot\mathrm{C}^{-2}\cdot\mathrm{L}$, $(\mathrm{kg}\cdot\mathrm{C}^{-2}\cdot\mathrm{m})$.
2) $[\varepsilon_{\mathrm{e}}] = \mathrm{M}^{-1}\cdot\mathrm{C}^{2}\cdot\mathrm{L}^{-3}\cdot\mathrm{T}^{2}$, $(\mathrm{kg}^{-1}\cdot\mathrm{C}^{2}\cdot\mathrm{m}^{-3}\cdot\mathrm{s}^{2})$.
3) $[q] = \mathrm{C}$, (C).
4) $[\varrho_{\mathrm{e}}] = \mathrm{C}\cdot\mathrm{L}^{-3}$, $(\mathrm{C}\cdot\mathrm{m}^{-3})$.
5) $[\boldsymbol{J}_{\mathrm{e}}] = \mathrm{C}\cdot\mathrm{L}^{-2}\cdot\mathrm{T}^{-1}$, $(\mathrm{C}\cdot\mathrm{m}^{-2}\cdot\mathrm{s}^{-1})$.
6) $[\boldsymbol{B}_{\mathrm{e}}] = \mathrm{M}\cdot\mathrm{C}^{-1}\cdot\mathrm{T}^{-1}$, $(\mathrm{kg}\cdot\mathrm{C}^{-1}\cdot\mathrm{s}^{-1})$.
7) $[\boldsymbol{E}_{\mathrm{e}}] = \mathrm{M}\cdot\mathrm{C}^{-1}\cdot\mathrm{L}\cdot\mathrm{T}^{-2}$, $(\mathrm{kg}\cdot\mathrm{C}^{-1}\cdot\mathrm{m}\cdot\mathrm{s}^{-2})$.

In the next section, we shall now present the proposed magnetic monopole field equations.

3. Magnetic Monopole Field Equations

A magnetic monopole is a hypothetical particle that has been proposed to exist in *Nature* as a singular magnetic charge, either a North Pole ($\mathcal{N}$) or a South Pole ($\mathcal{S}$), rather than the typical dipole nature of magnets, which have both a North and a South Pole. In classical electromagnetism, magnetic field lines always form closed loops, meaning that every magnet has two poles. The concept of magnetic monopoles introduces a symmetry between electric and magnetic fields, suggesting that there could be a duality in electromagnetic theory. If magnetic monopoles exist, they would have profound implications for our understanding of fundamental physics, including electromagnetism and gauge theories. Various experiments have been conducted to search for magnetic monopoles, but as of now, none have been conclusively found. Overall, magnetic monopoles remain an intriguing concept in theoretical physics, stimulating ongoing research and discussion.

As depicted in the top panel of Figure 1, in-accordance with convectional wisdom, when an electric monopole (typical positive or negative electric charge) is moving, it produces closed rings of magnetic fields around it and these magnetic fields are perpendicular to the direction of motion of the electric current. In the same manner, as depicted in the bottom panel of Figure 1, when a magnetic monopole is moving, it—*likewise*—produces closed rings of electric fields around it and these electric fields are perpendicular to the direction of motion of the magnetic current. The same set-up in-accordance with the proposed new magnetic monopole theory is shown in Figure 2.

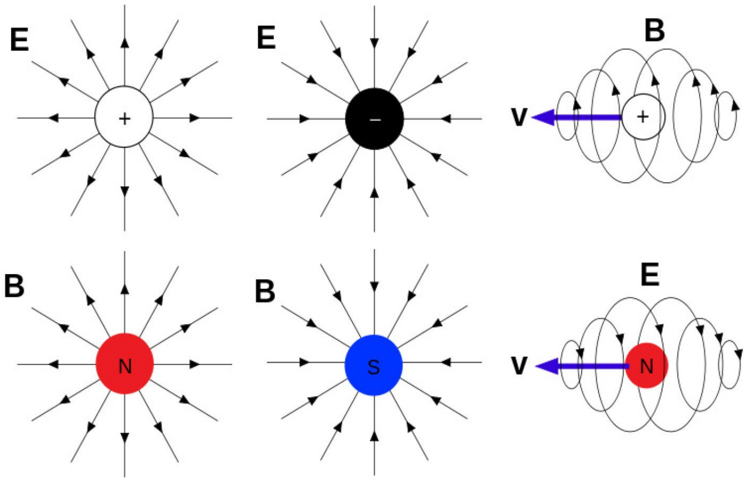

Figure 1. Top: Fields due to stationary and moving ($\boldsymbol{v}$) positive and negative electric monopole. **Bottom:** Fields due to stationary and moving ($\boldsymbol{v}$) positive and negative magnetic monopole. This is in-accordance with the proposed new magnetic monopole theory.

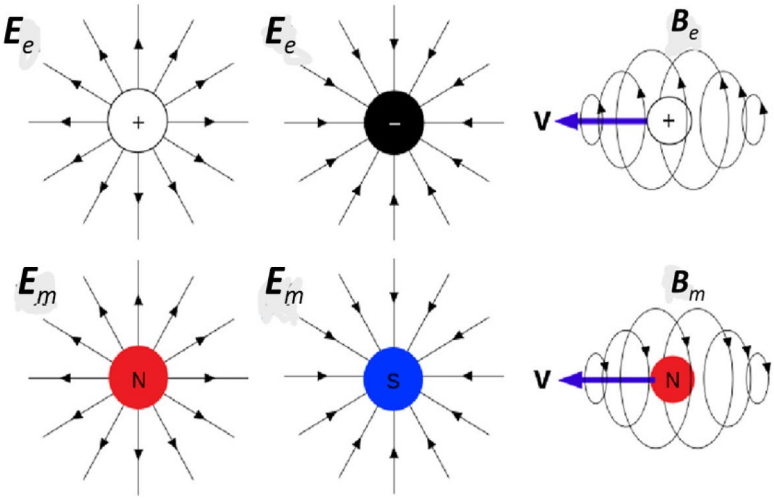

Figure 2. Top: Fields due to stationary and moving ($\boldsymbol{v}$) positive and negative electric monopole. **Bottom:** Fields due to stationary and moving ($\boldsymbol{v}$) positive and negative magnetic monopole. This is in-accordance with the proposed new magnetic monopole theory.

Just as the dynamics of electric monopoles are governed by Maxwell [5]'s equations of electrodynamics, if magnetic monopoles, there aught to be a similar set of equations that govern their dynamics. That is to say, in much the same way as the great Maxwell [5], wrote down the five equations that govern the behaviour of the electric monopole, we here hypothesize that a magnetic monopole is governed by the set of equations that where rejected by Maxwell [*i.e.*, Equation (2)] on his way to building his iconic equations. That is to say, we propose the following set of field equations for the magnetic monopole:

$$\nabla\cdot\left(c_m\boldsymbol{E}_m\right)=\mu_m c_m\varrho_m, \tag{16a}$$

$$\nabla\times\left(c_m\boldsymbol{E}_m\right)+\frac{1}{c_m}\frac{\partial\boldsymbol{B}_m}{\partial t}=0, \tag{16b}$$

$$\nabla\cdot\boldsymbol{B}_m=0, \tag{16c}$$

$$\nabla\times\boldsymbol{B}_m=\frac{\boldsymbol{J}_m}{\varepsilon_m}, \tag{16d}$$

and—*more importantly*—these magnetic charges obey the broken magnetic charge and current conservation law:

$$\frac{1}{c_m}\frac{\partial\left(\varrho_m c_m\right)}{\partial t}=-\nabla\cdot\boldsymbol{J}_m=0, \tag{17}$$

where: $\boldsymbol{E}_m$, is the magnetic monopole field and, $\boldsymbol{B}_m$, is the associated $\boldsymbol{B}$-field—we shall call this field the magneto $\boldsymbol{B}$-field, hence the subscript "m"; while, ϱ_m, and, $\boldsymbol{J}_m$, are the magneto monopole charge and current densities, with: ε_m and μ_m, being the magneto monopole permittivity and permeability of the medium in which the magnetic monopole finds itself, respectively, and: c_m, is the speed of propagation of the energy carried by the magneto monopole field.

The corresponding magneto monopole Lorentz equation of motion is:

$$\boldsymbol{F}_m=gc_m\boldsymbol{E}_m+g\left(\frac{\boldsymbol{v}}{c_m}\right)\times\boldsymbol{B}_m, \tag{18}$$

where: g and $\boldsymbol{v}$, is the charge and velocity of the magnetic monopole. Analogous to the speed of Light c, we have fore proposed to set the speed of magnetic monopole waves to travel at the speed c_m, where:

$$c_m=\frac{1}{\sqrt{\mu_m\varepsilon_m}}=\frac{c_{m0}}{\sqrt{\mu_m^r\varepsilon_m^r}}=\frac{c_{m0}}{n_m}, \tag{19}$$

where: c_{m0}, is the speed of the magneto monopole fields in a *vacuo*; μ_m^r, ε_m^r, and $n_m=\sqrt{\mu_m^r\varepsilon_m^r}$, are the relative magneto monopole permittivity and permeability of the given medium, and the magneto monopole refractive index of this same medium, respectively. Of the setting proposed in Equation (19), we must say that this setting is exogenous in nature, and the reason for this is that, this relation is not derived directly from the theory like is the case with the speed of Light c —hence it is exogenous. It is us that have made this setting for no other reason than for our own convenience, satisfaction and efficiency purposes. Our hope is that this speed will somehow turn-out to be the speed of sound in the given medium.

At this point, before we close this section, it is important to note that the dimensions and SI Units for all the physical quantities of Equations (16), (17) and (18) are as follows:

1) $[\mu_m] = \mathrm{M}\cdot\mathrm{C}^{-2}\cdot\mathrm{L}\quad(\mathrm{kg}\cdot\mathrm{C}^{-2}\cdot\mathrm{m})$
2) $[\varepsilon_m] = \mathrm{M}^{-1}\cdot\mathrm{C}^{2}\cdot\mathrm{L}^{-3}\cdot\mathrm{T}^{2}\quad(\mathrm{kg}^{-1}\cdot\mathrm{C}^{2}\cdot\mathrm{m}^{-3}\cdot\mathrm{s}^{2})$
3) $[g] = \mathrm{C}\cdot\mathrm{L}\cdot\mathrm{T}^{-1}\quad(\mathrm{C}\cdot\mathrm{m}\cdot\mathrm{s}^{-1})$
4) $[\varrho_m] = \mathrm{C}\cdot\mathrm{L}^{-2}\cdot\mathrm{T}^{-1}\quad(\mathrm{C}\cdot\mathrm{m}^{-2}\cdot\mathrm{s}^{-1})$
5) $[\boldsymbol{J}_m] = \mathrm{C}\cdot\mathrm{L}^{-1}\cdot\mathrm{T}^{-2}\quad(\mathrm{C}\cdot\mathrm{m}^{-1}\cdot\mathrm{s}^{-2})$
6) $[\boldsymbol{E}_m] = \mathrm{M}\cdot\mathrm{C}^{-1}\cdot\mathrm{T}^{-1}\quad(\mathrm{kg}\cdot\mathrm{C}^{-1}\cdot\mathrm{s}^{-1})$
7) $[\boldsymbol{B}_m] = \mathrm{M}\cdot\mathrm{C}^{-1}\cdot\mathrm{L}\cdot\mathrm{T}^{-2}\quad(\mathrm{kg}\cdot\mathrm{C}^{-1}\cdot\mathrm{m}\cdot\mathrm{s}^{-2})$

It is important to take note of the obvious fact that: $[\boldsymbol{B}_m] \neq [\boldsymbol{B}_e]$, but: $[\boldsymbol{B}_m] = [c][\boldsymbol{B}_e]$. What this essentially means is that while these $\boldsymbol{B}$-fields may share the same symbol and the divergent-less property, they are not one and the same thing—hence, the different subscripts "m" and "e", respectively. The same goes for: $\boldsymbol{E}_\mathrm{e}$, and $\boldsymbol{E}_m$, we have that: $[\boldsymbol{E}_\mathrm{e}] \neq [\boldsymbol{E}_m]$, but: $[\boldsymbol{E}_\mathrm{e}] = [c][\boldsymbol{E}_m]$. Actually: $[\boldsymbol{B}_\mathrm{e}] = [\boldsymbol{E}_m]$, and, $[\boldsymbol{E}_\mathrm{e}] = [\boldsymbol{B}_m]$; this does not mean that these fields are the same or may be related in an intimate way. In the next section, we shall now derive the heat equation from the three sets of Equations (16), (17), and (18).

4. Dyonic Matter

It is a well known fact that singular electric and magnetic monopoles result in irrevocable contradictions in the ensuring mathematics there of and this is because of the resulting symmetry in the resultant field equations. These equations do not make sense unless one invokes ingenious yet uncomfortable features to describe the magnetic monopole such as for example an infinite Dirac string. While searching for a noble way to evade this obvious difficulty, it occurred to us that if these monopoles (electric and magnetic) could exist simultaneously in a conjoined manner as a single unit and entity, it would not only be possible to obtain non-troublesome magnetic monopoles, but magnetic monopoles that can be used to build matter in a manner that appears to have some realistic correspondence with physical and natural reality as we know it. It is during this time what we stumbled upon the prolific *1965 Nobel Prize* winning American fundamental theoretical physicist—Julian Seymour Schwinger (1918-1994) [6]'s hypothetical *Dyons*.

That is to say, the hypothetical dyon was first proposed in 1968 by the German theoretical physicist—Daniel Zwanziger [7], and independently the following year in 1969, by Schwinger [6], as a phenomenological alternative to the explanation of quarks [6]. In his theory, Schwinger [6] extended the Dirac [3] quantization condition to the dyon and used the dyon-model to predict the existence of a particle with the properties of the J/Ψ meson prior to its eventual discovery in 1974. As depicted in **Figure 3**: on the left thereof is a dyon with a positive magnetic charge $(N, +g)$ carrying either a positive or negative electrical charge: $\pm\frac{1}{2}e$, while on the right is a dyon with a negative magnetic charge $(S,-g)$ and—*likewise*, this dyon carries a positive or negative electrical charge: $\pm\frac{1}{2}e$. In the next subsection, we shall describe how these dyons can be thought of insofar as how they can be envisioned in their construction of matter.

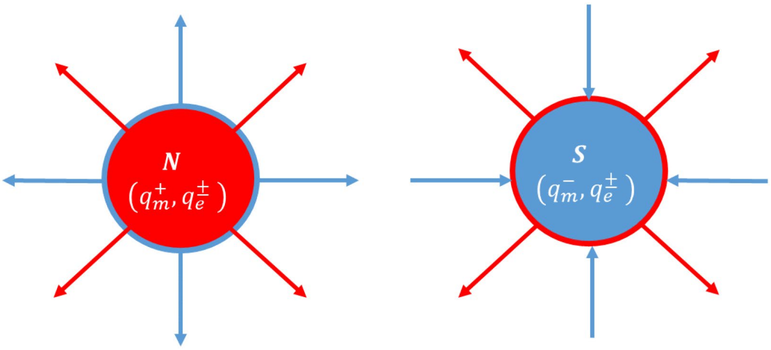

Figure 3. Diagram of Dyon Pair Leading to Electrically Neutral and Charged Particles: On the left is a dyon with a positive magnetic charge $(N,+g)$ and this dyon can carry positive or negative electrical charge $\pm\frac{1}{2}e$ while on the right isa dyon with a negative magnetic charge $(S,-g)$ and—likewise, this dyon can carry positive or negative electrical charge $\pm\frac{1}{2}e$.

As depicted in **Figure 4** and **Figure 5**, in much the same manner as Schwinger [6], we envision tightly bound magnetically neutral matter. This magnetic neutrality not only ensures that magnetic fields exist as closed loops but as dipoles and these constraints are literally forced by the broken conservation law: Equation (17), which not only requires that magnetic charges move in closed loops but must have a constant magnetic density throughout their life. However, unlike in Schwinger [6]'s speculative hypothesis, there is nothing in his theory that naturally compels his dyons to pair up into magnetically neutral bodies—let alone into a tightly bound and compact region of space. As already afore-stated, in the present suggestion or exploration, there is the broken conservation law [*namely*, Equation (17)] that these magnetic monopole charges must obey. It is this broken conservation law that distinguishes the present magnetic monopoles from any that have ever been proposed.

Of this broken conservation law, we must remark that it was during our exploration of the esoteric work of Maxwell [5] that we noted the intriguing properties associated with it. We began to wonder whether *Nature* had indeed found any utility in these properties. In examining Maxwell's work, our objective was to understand how he arrived at his famous equations. It was in this deep scrutiny that we realized there might be a significant promise for discovery in the very concepts that Maxwell had initially rejected—namely, the idea of "*less troublesome*" magnetic monopoles. This realization marked the beginning of our theoretical exploration of magnetic monopoles. By reconsidering Maxwell's insights through this lens, we aim to uncover deeper connections between electromagnetic theory and the potential existence of magnetic monopoles. This quest not only seeks to validate the properties inherent in this broken conservation law but also to explore the broader implications that such monopoles might have on our understanding of fundamental physics.

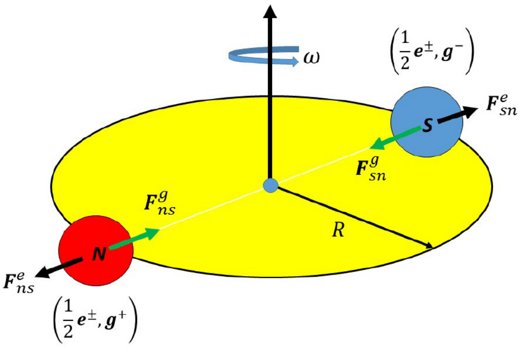

Figure 4. Dyon Pair Leading to Electrically Charged Particles. Such a particle is expected to have a magnetic dipole moment.

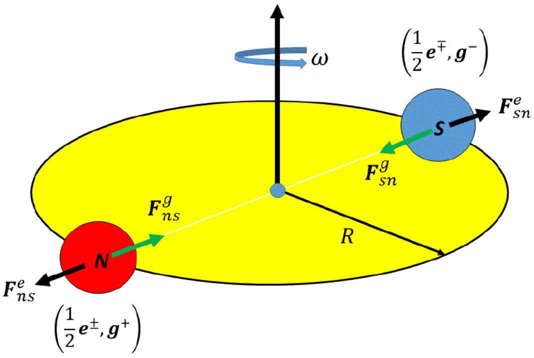

Figure 5. Dyon Pair Leading to Electrically Neutral Particles. Such a particle is expected to have both an electrical and magnetic dipole moment.

According to this broken conservation law [Equation (17)], because: $\partial \varrho_m / \partial t = 0$, these dyons must be confined in fixed magnetic charge density regions and in addition to this constraint, there is also the constraint: $\nabla \cdot \boldsymbol{J}_m = 0$, and because of this, it follows that these dyons are "*eternally incarcerated*" to traverse in closed circuits. Clearly, according to Newton's three laws of motion, it would be impossible for an isolated particle (whatever its nature—*exotic* or *mundane*) to satisfy these two condition [$\partial \varrho_m / \partial t = 0$ and $\nabla \cdot \boldsymbol{J}_m = 0$] unless there was a second particle with which to constantly interact with. In this way—*and this way alone*—the present dyons are compelled to stay confined a fixed region where they orbit about their common center of mass.

For fear of digression, we have refrained from further exploring the setup of dyons depicted in Figure 4 and Figure 5. We have decided to reserve this discussion for a later reading, as our current goal is to demonstrate that the energy carried by the magnetic monopole field of these dyons flows similarly to heat. This leads us to our seemingly audacious suggestion that heat and its associated random thermal motion may serve as compelling evidence that isolated magnetic charges could indeed exist. Our inability to observe these monopoles might reflect an indelible *Law of Nature*, suggesting that they exist only in bound pairs that traverse in closed loops. By establishing this analogy between heat transport and the behaviour of magnetic monopoles, we open up new avenues for understanding the fundamental nature of both thermal phenomena and magnetic charges. This inquiry not only challenges existing paradigms but also invites deeper reflection on the interconnectedness of physical concepts.

5. Fourier's Heat Equation

The theory [8] [9] of the transport of heat in materials was first developed in 1822 by the great, versatile and prolific French mathematician and physicist—Jean-Baptiste Joseph Fourier (1768-1830). Fourier is famous and best known for initiating the investigation of the mathematical series named after him—the *Fourier Series*, which eventually developed into *Fourier* and *Harmonic Analysis*, thus directly leading to important applications to problems of heat transfer and vibrations.

From his extensive studies on different materials and substances, Fourier [8] came to the conclusion that the temperature, T, across a given material varies as follows:

$$\frac{\partial T}{\partial t}=\kappa\nabla^{2}T, \tag{20}$$

where, for a homogeneous and isotropic medium: $\kappa > 0$, is the *thermal diffusivity constant* of the medium in question and the SI Units of this quantity are: $\mathrm{m^{2}\cdot s^{-1}}$. In addition to other physical phenomena, this Equation (20) describes the flow of heat in a homogeneous and isotropic medium, with: $T=T(x,y,z,t)$, being the temperature at the point (x,y,z) at time t. If the medium is not homogeneous and isotropic, then κ would not be a fixed coefficient as it would instead depend on (x,y,z) [*i.e.*, $\kappa=\kappa(x,y,z)$] and the resulting equation would have a slightly different form.

Since the heat energy, $\mathcal{Q}_{\mathrm{TD}}$, that manifests itself in the *Science of Thermodynamics* is such that: $\mathcal{Q}_{\mathrm{TD}}\propto T$, for our purposes, instead, we will write this Equation (20) in its most enduring form in-terms of the thermodynamic heat energy, $\mathcal{Q}_{\mathrm{TD}}$, as follows:

$$\frac{\partial \mathcal{Q}_{\mathrm{TD}}}{\partial t}=\kappa\nabla^{2}\mathcal{Q}_{\mathrm{TD}}. \tag{21}$$

Our aim here is to derive this heat transport Equation (21) from the energy field of magnetic monopoles and the hope in all this is to seek a plausible natural connection between magnetic monopoles and phonons.

To that daring end, we will start-off by taking the *curl* of Equations (16b) *&* (16d) and thereaafter making use of Equations (16a) *&* (16c), wherein the ensuring algebraic manipulations, one obtains the following equations:

$$\nabla^2\left(c_m \boldsymbol{E}_m^{\pm}\right)+\frac{\nabla\left(\varrho_m^{\pm} c_m\right)}{\varepsilon_m}=\mu_m \frac{\partial \boldsymbol{J}_m^{\pm}}{\partial t}, \tag{22a}$$

$$\nabla^2 \boldsymbol{B}_m^{\pm}=\mu_m \nabla \times \boldsymbol{J}_m^{\pm}. \tag{22b}$$

Succinctly—in Equation (22), we have purposefully written: $\boldsymbol{B}_m$ and $\boldsymbol{E}_m$, with a superscript "±"; the *plus case*: $\boldsymbol{B}_m^{+}$ and $\boldsymbol{E}_m^{+}$, corresponds to the case of a dyon carrying a positive magnetic charge ($+g$) and likewise, the *minus case*: $\boldsymbol{B}_m^{-}$ and $\boldsymbol{E}_m^{-}$, corresponds to the case of a dyon carrying a negative magnetic charge ($-g$).

Just as we could consider electrons moving inside a conducting wire under the influence of a potential different in the wire, let us consider a magnetic monopole moving inside a material medium under the influence of a potential different in this material; the Lorentz Equation (13) of motion for such a magnetic monopole is:

$$\frac{\partial \boldsymbol{J}_m^{\pm}}{\partial t}=\sigma_m c_m \boldsymbol{E}_m^{\pm}, \tag{23}$$

where the dyonic Lorentz $\boldsymbol{v}\times\boldsymbol{E}$ -term is equal to zero and analogously: σ_m, is the (magnetic monopole) conductance of the medium in question. Inserting Equation (23) into Equation (22a), and then:

1) Differentiating Equation (22b) with respect to time.

2) Substituting Equation (23) into the resulting equation generated in the previous step.

3) Make use of Equation (16b) in the equation of in the previous step by substituting for the term $\nabla\times\left(c_m \boldsymbol{E}_m\right)$.

4) Integrating the resulting equation with respect to time.

After executing the above mentioned algebraic operations, one will obtain the following equations:

$$\nabla^2\left(c_m \boldsymbol{E}_m^{\pm}\right)+\frac{\nabla\left(\varrho_m^{\pm} c_m\right)}{\varepsilon_m}=\mu_m \sigma_m \frac{\partial\left(c_m \boldsymbol{E}_m^{\pm}\right)}{\partial t}, \tag{24a}$$

$$\nabla^2 \boldsymbol{B}_m^{\pm}=\mu_m \sigma_m \frac{\partial \boldsymbol{B}_m^{\pm}}{\partial t}. \tag{24b}$$

As has already been explained in § (4), we envision matter to comprise of dyons [6] [7] and these dyons come in pairs of positive and negatively charged magnetic monopoles and these dyons couple in such a way that the resulting matter particle is magnetically neutral matter. For simplicity, let us in the moment just think if two interacting—*equal but oppositely charged*—magnetic charges without worrying about the dyonic nature of the setup. So doing we will have that the resultant $\boldsymbol{B}_m$, $\boldsymbol{E}_m$ and ϱ_m fields for such a system will be:

$$\boldsymbol{B}_m=\boldsymbol{B}_m^{+}+\boldsymbol{B}_m^{-}, \tag{25a}$$

$$\boldsymbol{E}_m=\boldsymbol{E}_m^{+}+\boldsymbol{E}_m^{-}, \tag{25b}$$

$$\varrho_m=\varrho_m^{+}+\varrho_m^{-}. \tag{25c}$$

In order to facilitate the easy visualization of the ensuing computations, we can de-compactify Equation (24) into two sets that describe the positively and negatively charged magnetic monopoles, using Equation (25). This approach will clarify the distinctions and interactions between these two types of magnetic charges.

Let us proceed with this de-compaction:

$$\nabla^2\left(c_m\boldsymbol{E}_m^+\right)+\frac{\nabla\left(\varrho_m^+c_m\right)}{\varepsilon_m}=\mu_m\sigma_m\frac{\partial\left(c_m\boldsymbol{E}_m^+\right)}{\partial t}, \tag{26a}$$

$$\nabla^2\boldsymbol{B}_m^+=\mu_m\sigma_m\frac{\partial\boldsymbol{B}_m^+}{\partial t}, \tag{26b}$$

$$\nabla^2\left(c_m\boldsymbol{E}_m^-\right)+\frac{\nabla\left(\varrho_m^-c_m\right)}{\varepsilon_m}=\mu_m\sigma_m\frac{\partial\left(c_m\boldsymbol{E}_m^-\right)}{\partial t}, \tag{26c}$$

$$\nabla^2\boldsymbol{B}_m^-=\mu_m\sigma_m\frac{\partial\boldsymbol{B}_m^-}{\partial t}, \tag{26d}$$

where Equations (26a &26c) describe the $\boldsymbol{B}$ -field of the positively charged magnetic monopole and likewise, Equations (26b &26d) describe the $\boldsymbol{E}$ -field of the the negatively charged magnetic monopole.

Adding these equations—*i.e.*, Equations (26a &26c) and Equations (26b &26d), and making use of the definitions given in Equation (25), we obtain the following:

$$\nabla^2\left(c_m\boldsymbol{E}_m\right)+\frac{\nabla\left(\varrho_mc_m\right)}{\varepsilon_m}=\mu_m\sigma_m\frac{\partial\left(c_m\boldsymbol{E}_m\right)}{\partial t}, \tag{27a}$$

$$\nabla^2\boldsymbol{B}_m=\mu_m\sigma_m\frac{\partial\boldsymbol{B}_m}{\partial t}. \tag{27b}$$

If as suggested—we are considering the union of a positive (*i.e.*, North Pole of magnetic charge "$+g$") and negatively (*i.e.*, South Pole of magnetic charge "$-g$") charged magnetic poles, it follows that:

$$\varrho_m=\varrho_m^++\varrho_m^-=0, \tag{28}$$

hence, the term: $\nabla\left(\varrho_mc_m\right)/\varepsilon_m$, in Equation (27a), will vanish—*i.e.*: $\nabla\left(\varrho_mc_m\right)/\varepsilon_m=0$. For: $\boldsymbol{B}_m$, and, $\boldsymbol{E}_m$, as given in Equations (25a) and (25b) respectively, we have that: $\boldsymbol{B}_m\neq 0$, and, $\boldsymbol{E}_m\neq 0$. The resultant equations from all this will be:

$$\nabla^2\left(c_m\boldsymbol{E}_m\right)=\mu_m\sigma_m\frac{\partial\left(c_m\boldsymbol{E}_m\right)}{\partial t}, \tag{29a}$$

$$\nabla^2\boldsymbol{B}_m=\mu_m\sigma_m\frac{\partial\boldsymbol{B}_m}{\partial t}. \tag{29b}$$

It is clear that the above equations have the same form as the heat equation presented in Equation (21). This similarity is encouraging. However, to establish a definitive connection between magnetic monopoles and the transport of heat, we must convincingly demonstrate that the energy associated with the monopoles is indeed governed by this same equation. This will involve a thorough analysis of the monopole energy dynamics and their correspondence to the principles outlined in the heat equation. By doing so, we can strengthen the argument for the relationship between these two phenomena.

To that very end, we will now transform these two equations into one that describes the transport of energy carried by the magnetic monopole. By the end of this exercise, one might be forgiven for being seduced into thinking that these hypothetical monopoles should indeed be the carriers of heat energy.

We will begin this process by expressing the $\left(\boldsymbol{E}_m, \boldsymbol{B}_m\right)$ vectors using the Riemann-Weber-Silberstein (RWS) three-vector formalism (see *e.g.*, Refs. [10]-[12]), as follows:

$$\boldsymbol{Q} = \sqrt{\frac{1}{2}\varepsilon_m}\left(\boldsymbol{B}_m + \imath c_m \boldsymbol{E}_m\right). \tag{30}$$

With Equation (30) now set, it follows that if we are to multiply Equation (29a) by $\sqrt{\varepsilon_m/2}$ and Equation (29b) by $\imath\sqrt{\varepsilon_m/2}$ and then adding the resultant two equations, one will obtain the following equation:

$$\kappa \nabla^2 \boldsymbol{Q} = \frac{\partial \boldsymbol{Q}}{\partial t}. \tag{31}$$

where: $\kappa = 1/\mu_m \sigma_m$. *So far, so good*! We shall further manipulate this equation so that—*for better or for worse*—we obtain from it, the heat equation [Equation (21)] that tells us about the transport of the energy carried by the monopole fields.

Let us now inch much closer to our *desideratum*. We know very well that—just like in the case of the electromagnetic phenomenon as presented in Equation (15), the total energy, $\mathcal{Q}_m$, stored in the magnetic monopole system of volume V should—*in a similar*—be such that: $\mathcal{Q}_m/V = \boldsymbol{Q}^* \cdot \boldsymbol{Q} = |\boldsymbol{Q}|^2$, *i.e.*:

$$\mathcal{Q}_m = \frac{1}{2}\varepsilon_m\left(|\boldsymbol{B}_m|^2 + c_m^2|\boldsymbol{E}_m|^2\right)V. \tag{32}$$

In the expression or dot-product: $\boldsymbol{Q}^* \cdot \boldsymbol{Q}$, the asterisk ($*$) represents the complex conjugate operator which acts on the given object.

With Equation (32) established, we can now convincingly derive the desired heat equation given in Equation (21) from the fundamental principles of theoretical physics. To accomplish this, we will need to further manipulate Equation (31) as follows:

1) Take the complex conjugate of Equation (31) and thereafter take the dot-product of the resulting equation with $\boldsymbol{Q}$.

2) Create another separate equation by taking the dot-product of Equation (31) with $\boldsymbol{Z}^*$.

After completing the above steps, we will have two separate equations. If we add these two equations together, we obtain the following equation:

$$\kappa\left[\boldsymbol{Q}\cdot\nabla^2\boldsymbol{Q}^* + \boldsymbol{Q}^*\cdot\nabla^2\boldsymbol{Q}\right] = \boldsymbol{Q}\cdot\frac{\partial \boldsymbol{Q}^*}{\partial t} + \boldsymbol{Q}^*\cdot\frac{\partial \boldsymbol{Q}}{\partial t}. \tag{33}$$

What is now required in order to arrive at our most sought-after result is to clean up Equation (33). To that end, we recognize that the right-hand side of this equation is structured in a way that allows us to simplify and reorganize it as follows:

$$\boldsymbol{Q}\cdot\frac{\partial\boldsymbol{Q}^*}{\partial t}+\boldsymbol{Q}^*\cdot\frac{\partial\boldsymbol{Q}}{\partial t}=\frac{\partial\left(\boldsymbol{Q}^*\boldsymbol{Q}\right)}{\partial t}=\frac{1}{V}\frac{\partial\mathcal{Q}_m}{\partial t},\tag{34}$$

and that the left hand-side of this Equation (33) is such that:

$$\boldsymbol{Q}\cdot\nabla^2\boldsymbol{Q}^*+\boldsymbol{Q}^*\cdot\nabla^2\boldsymbol{Q}=\frac{\nabla^2\mathcal{Q}_m}{V}-2\left|\nabla\cdot\boldsymbol{Z}\right|^2.\tag{35}$$

The term: $\left|\nabla\cdot\boldsymbol{Z}\right|^2=0$. To see this, from Equation (30), we know that: $\nabla\cdot\boldsymbol{Q}=\sqrt{\varepsilon_m/2}\left(\nabla\cdot\boldsymbol{B}_m+\imath c_m\nabla\cdot\boldsymbol{E}_m\right)$. By definition: $\nabla\cdot\boldsymbol{B}_m=0$, and, $\nabla\cdot\boldsymbol{E}_m=\mu_m\varrho_m$; and from the arguments presented leading to Equation (28), we have that: $\varrho_m=0$, leading to: $\nabla\cdot\boldsymbol{E}_m=0$, and all this leads to: $\nabla\cdot\boldsymbol{Q}=0$, and: $\left|\nabla\cdot\boldsymbol{Q}\right|^2=0$, hence, Equation (35), reduces to:

$$\boldsymbol{Q}\cdot\nabla^2\boldsymbol{Q}^*+\boldsymbol{Q}^*\cdot\nabla^2\boldsymbol{Q}=\frac{\nabla^2\mathcal{Q}_m}{V},\tag{36}$$

thus, from these equations [*i.e.*, Equations (33), (34) *&* (36)], as *per* our *desideratum*, we obtain:

$$\frac{\partial\mathcal{Q}_m}{\partial t}=\kappa\nabla^2\mathcal{Q}_m.\tag{37}$$

Clearly and without any doubt, this equation is the well-known and much-desired heat equation given in Equation (21). If, by some kind of divine providence, we are able to further validate this connection, it would reinforce our hypothesis that magnetic monopoles could indeed serve as carriers of heat energy. This profound relationship would not only deepen our understanding of monopole dynamics but also illuminate new pathways for exploring energy transport phenomena in theoretical physics. That is to say, if, by some kind of divine providence:

$$\mathcal{Q}_m\equiv\mathcal{Q}_{\text{TD}},\tag{38}$$

then, we can safely conclude that the phenomenon of the transport of heat—*and, more generally*—the *Science of Thermodynamics* is driven by the magnetic monopole part of Schwinger [6]'s hypothetical dyons. At any rate imaginable, this is an intriguing result, if not a profoundly interesting one!

To fully appreciate this outcome, we should engage in some post-pondering on its implications:

1) Theoretical Insights: What does this reveal about the nature of monopoles and their role in fundamental physics?

2) Possible Practical Applications: Could this understanding lead to new technologies or methods for energy management?

3) Further Exploration: What experimental approaches could be taken to explore this relationship more deeply?

By reflecting on these aspects, we can better grasp the significance of our findings and their potential impact on both theoretical and applied physics.

6. Contemplation

We need to engage in some serious theoretical and philosophical contemplation to fully understand and appreciate the intriguing result derived above. What have we accomplished in the previous section? First and foremost, we must acknowledge that we have derived the heat equation from what we refer to as the field equations of the magnetic monopole. The resulting heat equation closely relates to the transport of energy carried by the monopole field and resembles the form and structure of Fourier's heat equation [8]. Given that we have envisioned these monopoles as carrying not only magnetic charge but also electrical charge, one might be forgiven for briefly imagining that this dyonic monopole energy could indeed represent the heat energy we have long pondered about, questioning what heat truly is.

In its most basic form, what we have accomplished in the previous section is a fundamental derivation of the heat equation. It is noteworthy that since this heat equation was conceived experimentally by Fourier in 1822 [8], it has not been presented with such a clear foundation from the fundamental principles of theoretical physics as we have done here. If this assertion is indeed true, it underscores the significance of this exercise for the fundamental theoretical physicist.

Clearly, based on what we have presented leading to the fundamental derivation of the heat equation, we are mathematically justified in conceiving of heat as a form of energy arising from certain vector fields ($\boldsymbol{E}_m$ and $\boldsymbol{B}_m$) similar to Maxwell's [5] $\boldsymbol{E}$ and $\boldsymbol{B}$ fields in electrodynamics—*albeit*, these $\boldsymbol{E}_m$ and $\boldsymbol{B}_m$ fields obey a broken continuity equation. These fields originate from a *hithereto* previously unknown magnetic monopole charge, which we have boldly hypothesized to be the elusive magnetic monopole! The next and most natural question that arises from this is:

> *If our hypothetical monopole is indeed what carries heat energy, it follows that magnetic monopoles must be ubiquitous, given that all matter carries heat energy. This raises the question: how have we not been able to detect these magnetic monopoles, which should be present everywhere according to our bold hypothesis?*

As mentioned in various forms throughout this reading, the answer to this important question may indeed lie with the seemingly simple and mundane broken continuity equation (17).

In other words, the observance of the broken continuity equation (17) by the proposed magnetic monopoles has two significant implications. The first, derived from: $\mathrm{d}\varrho_m/\mathrm{d}t = 0$, indicates that the density of these monopoles must be a constant over time. The invariable and unavoidable consequence of this is that they must be eternally confined within a well-defined volume of space. The second implication, arising from: $\nabla \cdot \boldsymbol{J}_m = 0$, suggests that these monopoles must move in spatially closed loops, further contributing to their eternal confinement as they are required to traverse these closed paths within the finite space that *Nature* has allocated for them!

7. General Discussion

Perhaps, after going through this reading, it is appropriate to reiterate the question: *Do magnetic monopoles exist? If they do, where are they?* These pressing questions often occupy the curious and searching minds of leading theoretical physicists. The inquiries regarding the existence and nature of magnetic monopoles frequently arise in the context of electromagnetic duality. Since their prediction by Dirac [3] [4], they have yet to be observed in *Nature*, making their quest one of the *Holy Grails of Modern Physics*. Nonetheless, there have been invigorating, *albeit inconclusive*, reports of close encounters with magnetic monopoles in the literature [13]-[24].

In this reading, we have boldly attempted to provide a somewhat enduring answer to the intriguing question regarding the whereabouts of magnetic monopoles by closely linking their energy—through Fourier [8]'s heat equation—to the thermodynamic energy of heat. If this connection holds true, then the *Science of Thermodynamics* may indeed be influenced by the energy field of magnetic monopoles. This newly discovered link between the energy of magnetic monopoles and heat is so compelling that it warrants further contemplation on the true implications of this fascinating result thereof.

At this juncture, it is important to note that most theories regarding magnetic monopoles are based on the concept of electromagnetic duality—essentially, a perfect symmetry between magnetic and electric charges. Upon examining the challenges associated with magnetic monopoles, one can see that this electromagnetic duality is the root of many issues, such as the infinite Dirac string, among others. In our proposed theory, this duality is effectively broken by the mere observance of the broken conservation law [*i.e.*, Equation (17)] by the proposed magnetic monopoles. This broken conservation law allows us to formulate a theory of magnetic monopoles that is free from singularities and the various problems that have plagued previous magnetic monopole theories. For this reason, we firmly believe that the magnetic monopoles we have proposed differ fundamentally from those suggested by earlier explorers in this field.

Despite having eluded detection thus far, magnetic monopoles remain a significant and active area of exploration—both theoretically and experimentally. This underscores their importance and relevance to fundamental theoretical and experimental physics. Notably, even though they have not been observed since Dirac's [3] speculation about their existence, extensive reviews [25]-[34] on this topic have been conducted over the years. Additionally, ingenious and dedicated experimental efforts [35]-[37] have also been made in the quest to find this elusive Dirac particle.

It is interesting to note that some condensed matter theories propose structures known as flux tubes, which are superficially similar to magnetic monopoles. Since around 2009, these structures have led to numerous misleading reports in the mainstream media about the detection of the long-sought magnetic monopoles. The ends of these flux tubes form a magnetic dipole, and they move independently of one another. Because of this, they can often be treated as independent magnetic monopole quasi-particles for various purposes. If detected, these flux tubes could create a false impression of magnetic monopoles. As these condensed matter systems continue to be an area of active research, it is crucial to revisit and reanalyze these claims in light of the ideas proposed herein.

As noted on page (12), we have refrained from delving deeper into the setup of dyons depicted in **Figure 4** and **Figure 5** to avoid digression. We have chosen to leave this exploration for a later reading. Our primary aim in the present discussion is to demonstrate that the energy carried by the magnetic monopole field of these dyons flows in a manner analogous to heat. This leads us to our seemingly audacious suggestion that heat and its associated random thermal motion may serve as the clearest evidence that isolated magnetic charges could indeed exist. Our inability to observe them might be an indelible Law of Nature, as they likely exist in bound pairs that traverse closed loops.

As we conclude this reading, we hope the reader no longer wonders about the title: *Are Phonons and Random Thermal Motions Evidence of Magnetic Monopoles?* Before this discussion, such curiosity was indeed justified, as no connection—*however remote*—between magnetic monopoles and phonons had been established in the scientific literature available to us. Given that these dyons are quantum particles at the most elementary and fundamental level of existence, one might be forgiven for considering whether *Thermodynamic Randomness* has any relation to the phenomenon of *Quantum Randomness* exhibited by all matter. Are these not, in fact, one and the same thing? That is to say:

$$\left\langle \mathit{Thermodynamic\ Randomness} \right\rangle \equiv \left\langle \mathit{Quantum\ Randomness} \right\rangle. \tag{39}$$

We shall leave these torrential and polemical matters for another day.

8. Conclusions

Assuming the acceptability of the thesis here presented, then, one can safely conclude that:

1) Aside from the concept of magnetic monopoles, the *Heat Equation of Fourier* [8] can be independently derived from a fundamental set of equations [*i.e.*, Equations (16) and (17)] that were rejected by James Clerk Maxwell [5] during his journey to discover his iconic equations governing the phenomena of electrodynamics.

2) If it is suggested that: $\mathcal{Q}_m \equiv \mathcal{Q}_{\text{TD}}$, meaning the energy field $\mathcal{Q}_m$ carried by the magnetic charges making up dyons is indeed the heat energy $\mathcal{Q}_{\text{TD}}$ manifesting in the *Science of Thermodynamics*, then, the very existence of the *Science of Thermodynamics* may serve as sufficient proof for the existence of singular magnetic charges.

Acknowledgements

We express our gratitude to the National University of Science and Technology, Zimbabwe, for the financial support provided through Research Board Grant Number RBD48/25, which helped cover the publication costs.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

[1] Kittel, C. and Kroemer, H. (1980) Thermal Physics. 2nd Edition, W. H. Freeman and Company.

[2] Kittel, C. (1986) Introduction to Solid State Physics. 6th Edition, John Wiley & Sons, Inc., 140-151.

[3] Dirac, P.A.M. (1931) Quantised Singularities in the Electromagnetic Field. *Proceedings of the Royal Society of London A*: *Mathematical*, *Physical and Engineering Sciences*, **133**, 60-72.

[4] Dirac, P.A.M. (1948) The Theory of Magnetic Poles. *Physical Review*, **74**, 817-830. https://doi.org/10.1103/physrev.74.817

[5] Maxwell, J.C. (1865) A Dynamical Theory of the Electromagnetic Field. *Philosophical Transactions of the Royal Society*, **155**, 459-512.

[6] Schwinger, J. (1969) A Magnetic Model of Matter. *Science*, **165**, 757-761. https://doi.org/10.1126/science.165.3895.757

[7] Zwanziger, D. (1968) Quantum Field Theory of Particles with Both Electric and Magnetic Charges. *Physical Review*, **176**, 1489-1495. https://doi.org/10.1103/physrev.176.1489

[8] Fourier, J.-B.J. (1822) Th'eorie Analytique de la Chaleur.

[9] Truesdell, C. (1980) The Tragicomical History of Thermodynamics, 1822-1854. Springer-Verlag.

[10] Sebens, C.T. (2019) Electromagnetism as Quantum Physics. *Foundations of Physics*, **49**, 365-389. https://doi.org/10.1007/s10701-019-00253-3

[11] Kiessling, M.K. and Tahvildar-Zadeh, A.S. (2018) On the Quantum-Mechanics of a Single Photon. *Journal of Mathematical Physics*, **59**, Article ID: 112302. https://doi.org/10.1063/1.5021066

[12] Bialynicki-Birula, I. (1996) Photon Wave Function. In: Wolf, E., Ed., *Progress in Optics*, Elsevier, 245-294.

[13] Gibney, E. (2014) Quantum Cloud Simulates Magnetic Monopole. *Nature*. https://doi.org/10.1038/nature.2014.14612

[14] Ray, M.W., Ruokokoski, E., Kandel, S., Möttönen, M. and Hall, D.S. (2014) Observation of Dirac Monopoles in a Synthetic Magnetic Field. *Nature*, **505**, 657-660. https://doi.org/10.1038/nature12954

[15] Giblin, S.R., Bramwell, S.T., Holdsworth, P.C.W., Prabhakaran, D. and Terry, I. (2011) Creation and Measurement of Long-Lived Magnetic Monopole Currents in Spin Ice. *Nature Physics*, **7**, 252-258. https://doi.org/10.1038/nphys1896

[16] Bramwell, S.T., Giblin, S.R., Calder, S., Aldus, R., Prabhakaran, D. and Fennell, T. (2009) Measurement of the Charge and Current of Magnetic Monopoles in Spin Ice. *Nature*, **461**, 956-959. https://doi.org/10.1038/nature08500

[17] Brumfiel, G. (2009) "Overwhelming" Evidence for Monopoles. *Nature*. https://doi.org/10.1038/news.2009.881

[18] Fennell, T., Deen, P.P., Wildes, A.R., Schmalzl, K., Prabhakaran, D., Boothroyd, A.T., *et al.* (2009) Magnetic Coulomb Phase in the Spin Ice $HO_2Ti_2O_7$. *Science*, **326**, 415-417. https://doi.org/10.1126/science.1177582

[19] Kadowaki, H., Doi, N., Aoki, Y., Tabata, Y., J. Sato, T., W. Lynn, J., *et al.* (2009) Observation of Magnetic Monopoles in Spin Ice. *Journal of the Physical Society of Japan*, **78**, Article ID: 103706. https://doi.org/10.1143/jpsj.78.103706

[20] Morris, D.J.P., Tennant, D.A., Grigera, S.A., Klemke, B., Castelnovo, C., Moessner, R., *et al.* (2009) Dirac Strings and Magnetic Monopoles in the Spin Ice $Dy_2Ti_2O_7$. *Science*, **326**, 411-414. https://doi.org/10.1126/science.1178868

[21] Castelnovo, C., Moessner, R. and Sondhi, S.L. (2008) Magnetic Monopoles in Spin Ice. *Nature*, **451**, 42-45. https://doi.org/10.1038/nature06433

[22] Cabrera, B. (1982) First Results from a Superconductive Detector for Moving Magnetic Monopoles. *Physical Review Letters*, **48**, 1378-1381. https://doi.org/10.1103/physrevlett.48.1378

[23] Price, P.B., Shirk, E.K., Osborne, W.Z. and Pinsky, L.S. (1975) Evidence for Detection of a Moving Magnetic Monopole. *Physical Review Letters*, **35**, 487-490. https://doi.org/10.1103/physrevlett.35.487

[24] Cohen, H.A. (1973) On the Dirac Monopole Potential. *Progress of Theoretical Physics*, **50**, 691-696. https://doi.org/10.1143/ptp.50.691

[25] Heras, R. (2018) Dirac Quantisation Condition: A Comprehensive Review. *Contemporary Physics*, **59**, 331-355. https://doi.org/10.1080/00107514.2018.1527974

[26] Rajantie, A. (2012) Introduction to Magnetic Monopoles. *Contemporary Physics*, **53**, 195-211. https://doi.org/10.1080/00107514.2012.685693

[27] Lynden-Bell, D. and Nouri-Zonoz, M. (1998) Classical Monopoles: Newton, NUT Space, Gravomagnetic Lensing, and Atomic Spectra. *Reviews of Modern Physics*, **70**, 427-445. https://doi.org/10.1103/revmodphys.70.427

[28] Alvarez-Gaumé, L. and Hassan, S.F. (1997) Introduction Tos-Duality in N = 2 Supersymmetric Gauge Theories (a Pedagogical Review of the Work of Seiberg and Witten). *Fortschritte der Physik/Progress of Physics*, **45**, 159-236. https://doi.org/10.1002/prop.2190450302

[29] Harvey, J.A. (1995) Magnetic Monopoles, Duality, and Supersymmetry. In: Gava, E., Masiero, A., Narain, K.S., Randjbardaemi, S. and Shafi, Q., Eds., 1995 *Summer School in High Energy Physics and Cosmology*, *Volume* 12 *of the ICTP Series in Theoretical Physics*, ICTP, World Scientific Publishers Co. Pvt. Ltd., 66-125.

[30] Blagojević, M. and Senjanović, P. (1988) The Quantum Field Theory of Electric and Magnetic Charge. *Physics Reports*, **157**, 233-346. https://doi.org/10.1016/0370-1573(88)90098-1

[31] Rubakov, V.A. (1988) Monopole Catalysis of Proton Decay. *Reports on Progress in Physics*, **51**, 189-241. https://doi.org/10.1088/0034-4885/51/2/002

[32] Preskill, J. (1984) Magnetic Monopoles. *Annual Review of Nuclear and Particle Science*, **34**, 461-530. https://doi.org/10.1146/annurev.ns.34.120184.002333

[33] Coleman, S.R. (1982) The Magnetic Monopole Fifty Years Later. In: *Les Houches Summer School of Theoretical Physics: Laser-Plasma Interactions*, 461-552.

[34] Goddard, P. and Olive, D.I. (1978) Magnetic Monopoles in Gauge Field Theories. *Reports on Progress in Physics*, **41**, 1357-1437. https://doi.org/10.1088/0034-4885/41/9/001

[35] Abbott, B., Abolins, M., Acharya, B.S., *et al.* (1998) Search for Heavy Pointlike Dirac Monopoles. *Physical Review Letters*, **81**, 524-529.

[36] Acciarri, M., Adam, A., Adriani, O., *et al.* (1995) Search for Anomalous $Z \to \gamma\gamma\gamma$ Events at LEP. *Physics Letters B*, **345**, 609-616.

[37] Rubakov, V.A. (1982) Adler-Bell-Jackiw Anomaly and Fermion-Number Breaking in the Presence of a Magnetic Monopole. *Nuclear Physics B*, **203**, 311-348. https://doi.org/10.1016/0550-3213(82)90034-7